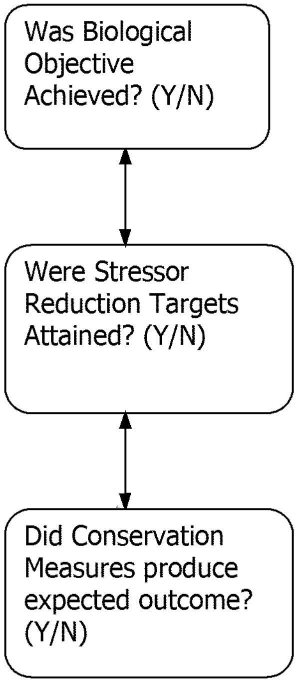
Decision Making



Has the survival of juvenile Chinook salmon emigrating through the Delta improved? (Is the Biologic Objective being achieved?)

- **Yes** – evaluate stressor reduction targets associated with predation, entrainment, toxics, levees (habitat), and water facilities and operations (what worked?)
  - Are one or more of the Stressor Reduction Targets being met?
    - **Yes** – evaluate individual Conservation Measure(s) (what worked? antagonistic, synergistic effects)
      - Did the Conservation Measure(s) achieve expected outcome? (e.g., Did CM15 – Predator Control achieve its expected outcome?)
        - **Yes** – Continue to implement and evaluate against controlled/uncontrolled stressors to determine level of support for each Conservation Measure
        - **No** – Evaluate other relevant Conservation Measure(s) and revise Conservation Measure to (1) achieve target? (2) reduce investment? (3) eliminate Conservation Measure?
    - **No** – further evaluate relevance of Conservation Measure(s) and associated target(s) for achieving biological objective, possibly (1) relax this target(s)? (2) postpone other relevant Conservation Measure(s)
- **No** – evaluate stressor reduction targets associated with predation, entrainment, toxics, levees (habitat), and water facilities and operations
  - Are one or more of the Stressor Reduction Targets being met?
    - **Yes** – evaluate other stressor reduction targets, increase this particular stressor reduction target?
    - **No** – evaluate Conservation Measure(s), increase investment in efforts to achieve stressor reduction target
      - Did the Conservation Measure(s) achieve expected outcome? (e.g., Did CM15 – Predator Control achieve its expected outcome?)
        - **Yes** – evaluate other relevant Conservation Measure(s), consider revising Conservation Measure to incremental contribution to target.
        - **No** – evaluate against other stressors (how much support is there for this Conservation Measure?), consider revising Conservation Measure to improve likelihood of achieving expected outcome, possibly discontinue implementation of this Conservation Measure and direct resources to other actions.

Table 1 – Logic Chain - Enhanced through-Delta survival of juvenile Spring-run Chinook salmon

BDCP Goal	BDCP Objective	Stressor (note 1)	Stressor Target	Conservation Measure	Projected Outcome	Metrics	Observed Outcome	Key Uncertainties (Note 3)
SRCS1 (abundance) – Improved survival (to contribute to increased abundance) of emigrating juvenile spring-run salmon through the Plan Area	SRCS1.1 (juvenile survival) – achieve a 4-year running average through-Delta survival rate, which will result in stable or expanding population within 15 years of BDCP implementation	Predation	[x]% reduction in predation by [Year] Identify and assess alternative migratory pathways in terms of adequacy, frequency of availability and routing schemes (stressor reduction target assoc with Objective SRCS3.1 [Habitat], p.3-138, Section 3.3.5.4).	CM15 – **Predator control** at "hot spots" – (1) focused removal of predators (2) removal or modification of artificial structures to reduce habitat for predators	Reduce predator density in the Plan Area to achieve a measurable decrease in Spring-run Chinook salmon predation within 15 years of Plan implementation	Diversity, abundance/density, distribution, and size of predatory fish within specific reaches/locations Diversity, abundance, and size of predatory fish removed Spatial distribution and prevalence of predator "hot spots" Number of structures and/or boats removed/modified within specific reaches/regions per year		22, 23, 24
				CM2 - Yolo Bypass - **alternative migration route** (reduced predation risk - space, cover, enhanced growth/condition)	Provide at least one alternative migratory pathway for the lower Sacramento in >[x]% of years within 10 years of implementation [x]% of population uses bypass when inundated	Return frequency of bypass activation with appropriate inundation regime Proportion of the juveniles that enter the bypass when inundated Growth and survival		6, 16, 24
				CM16 – Non-physical barriers – **alternative migration route**	[x]% of population avoids migratory pathways that have high predation risk	Quantification of predation at the barrier site Deterrence efficiency (D=E/[E+U]) Protection efficiency (P=S/[S+O]) **(note 2)**		25, 26
				CM13 – Invasive aquatic vegetation control – **control/reduce habitat for predatory fishes**	Prevent introduction of new invasive aquatic vegetation. Control/reduce existing populations, notably those	Spatial extent of invasive aquatic vegetation by species Effectiveness of prevention/control measures		15, 18, 20

					in sensitive areas (e.g., near or upstream of restoration areas)			
				CM1 – Water facilities and operations	Provide sufficient bypass flows to limit predation in the vicinity of the north Delta intakes to [x]% of the estimated juvenile abundance	Timing, duration, magnitude of bypass flows		
		Entrainment (project diversions)	[x]% reduction in entrainment at project diversions by [Year] Identify and assess alternative migratory pathways in terms of adequacy, frequency of availability and routing schemes (stressor reduction target assoc with Objective SRCS3.1 [Habitat], p.3-138, Section 3.3.5.4)	CM1 – Water facilities and operations	Reduce mortality in CVP and SWP south Delta facilities to less than 1% for fish entering facilities within 5 years of implementation (p. 3-136, stressor reduction target) Provide sufficient bypass flows and other operational criteria to limit entrainment at the north Delta intakes to [x]% of the fish emigrating past the facilities	Losses at south Delta facilities (salvage, entrainment, loss). **(Note 4)** Losses at the north Delta facilities (salvage, entrainment, loss).		2, 4
				CM2 - Yolo Bypass - **alternative migration route** (reduced entrainment risk)	See above	See above		6
				CM16 – Non-physical barriers – **alternative migration route**	[x]% of population that avoids migratory pathways that are of high risk for predation and/or entrainment	Deterrence efficiency Protection efficiency **(Note 2)**		25, 26
		Entrain-ment (non-project diversions)	Minimize potential entrainment at non-project diversions	CM21 – Non-project diversions		Entrainment at non-project diversions (subset to be addressed not yet determined) Effectiveness of different techniques (consolidation to fewer diversions,		

						change location, removal, screen enhancements, etc.)		
		Delta Cross Channel		CM1 – Water facilities and operations – **Gate operations**		Timing and duration of gate closures		
		Levees	Increase availability of floodplain habitat by 1,000 acres within 15 years of Plan implementation, channel margin habitat by 5 miles within 10 years of Plan implementation, increase riparian communities by 2,300 acres within 15 years of Plan implementation, and tidal communities by 14,000 acres within the first 10 years.	CM2 – Yolo Bypass	Modify Yolo Bypass to increase the frequency, duration, and magnitude of floodplain inundation.	Inundation regime (return frequency, timing, magnitude, duration)		6
				CM6 – Channel margin enhancement	Restore 20 linear miles of channel margin habitat by improving channel geometry and restoring riparian, marsh, and mudflat communities on the inboard side of levees (≥5 miles by year 10, then phase in 5 mile increments at years 20, 25, and 30)	Acres restored Identify metrics to evaluate: physical/chemical, vegetation, fish, food web, and processes		
				CM4 – Tidal natural communities restoration	Provide for restoration of ≥65,000 acres of tidal perennial aquatic, tidal mudflat, tidal freshwater emergent wetland, and tidal brackish emergent wetland natural communities. Phased to develop (=reintroduction of tidal inundation) 14,000 acres within first 10 years, 25,000 acres (cumulative) by year 15, and 65,000 acres (cumulative) by year 40.	Acres restored Identify metrics to evaluate: physical/chemical, vegetation, fish, food web, and processes		8, 9, 10. 11, 15
				CM5 – Seasonally inundated floodplain restoration	Set back river levees and restore 10,000 acres of seasonally inundated floodplains. Phased	Acres restored Identify metrics to evaluate: physical/chemical,		

					implementation with ≥1,000 acres restored by year 15 and 10,000 acres (cumulative) by year 40.	vegetation, fish, food web, and processes		
				CM7 – Riparian natural community restoration	Restore 5,000 acres of riparian forest and scrub in assoc. with CM4, CM5, and CM6. Phased implementation with 2,300 acres by year 15 and 5,000 acres (cumulative) by year 40	Acres restored Identify metrics to evaluate: vegetation, riparian shading, structure, food web, etc.		
		Toxics	Contaminants do not exceed chronic effect concentrations	CM19 – Urban stormwater treatment	Reduce stormwater pollutant loads to the Delta from specific locations (to be determined) within 5 years of Plan implementation	Concentration/loading of: ammonia pyrethroids organophosphates copper **(Note 1)**		
				CM1 – Water facilities and operations				
		Hatchery Influence (increase d straying)						

Notes
1. Source: Williams. 2010. DRERIP salmonid conceptual model
2. Deterrence Efficiency – D=E/(E+U), where D=deterrence efficiency, E=number of fish deterred, and U=number of fish undeterred
 Protection Efficiency – P=S/(S+O), where P=protection efficiency, S=number of fish passing down into the desired route/river, and O=number of fish passing down into the undesired route/river
3. Based on updated version of Table 3.E-8 provided by Chris Earle on 23 April 2012, a copy of the table is included at the end of this document
4. "Daily *salvage* is the number of fish of given characteristics (species, stage, length) estimated to have entered a fish facility in a day. Daily *entrainment* is the estimated net number of fish that arrived at the entrance to the fish facility per day, i.e., those that arrived and did not leave the area except via the fish facilities. Entrainment exceeds salvage because of mortality in the waterways, leading to the export facilities and losses through the louvers. Daily *loss* is the estimated number entrained that were not subsequently salvaged and returned alive to the Estuary, which includes losses both before and after the salvage process; these are also termed "direct" losses because they are directly attributable to pumping operations" (Kimmerer 2008).

Global Goal – Removal of the Central Valley spring-run Chinook salmon ESU from the Federal List of Endangered and Threatened Wildlife (NMFS 2009). According to the NMFS draft recovery plan (2009), recovery and long-term sustainability requires:

1) Adequate protection for replacement of losses due to natural mortality (disease and stochastic events);
2) Sufficient genetic robustness to avoid inbreeding depression and allow for adaptation;
3) Sufficient habitat (type, amount, and quality) for long-term population maintenance, and;
4) Elimination or control of threats.

Given the diverse array of factors that affect the sustainability of spring-run Chinook salmon populations in the Central Valley, progress toward achieving recovery of this ESU will involve actions on the part of multiple agencies/organizations, working in the context of changing natural processes outside of management control. Restoration actions must be considered in the context of the species' life cycle, and at both site-specific and system-wide scales. Because so much of the Chinook salmon life cycle occurs outside of the Delta, and survival in these other environments can be highly variable, even major improvements in Delta conditions would be unlikely to give a clear signal in population level abundance data until many years have passed (Bradford et al. 2005, as cited in Williams 2010). Therefore, monitoring will need to focus on attributes (e.g., through Delta survival of juvenile migrants) that are potentially more useful for assessing effectiveness of individual actions/Conservation Measures implemented in the Delta, in association with the BDCP. The following have been proposed as a species specific BDCP goal and objective for spring-run Chinook salmon.

BDCP Global Goal SRCS1 (Abundance) - Improved survival (to contribute to increased abundance) of emigrating juvenile spring-run salmon through the Plan Area

> <u>BDCP Global Objective SRCS1.1 (Juvenile Survival)</u> - Achieve a 4-year running average through-Delta survival rate, which will result in stable or expanding population within 15 years of BDCP implementation.

A number of drivers influence the probability of juvenile salmonids successfully emigrating through the Delta. Drivers that exert negative pressure on this transition probability, with varying levels of understanding, importance, and predictability, include predation, project diversions, small diversions, Delta cross channel gate operations, toxics, levees, hatchery influence, dams (lower spring flows), and climate change (elevated water temperature and more variable winter flows and lower spring flows) (Williams 2010). A number of conservation measures contain actions that are designed to contribute to achieving Goal SRCS1 and Objective SRCS1.1 (see Table 1). The following represents a partial list of biological goals and objectives that have been advanced to address several of the drivers that have been identified as having a negative influence on the likelihood of successful juvenile salmon migration through the Delta:

BDCP Goal SRCS3 – Improved availability of floodplain and channel margin habitat to support spring-run migration and rearing through the Delta.

<u>BDCP Objective SRCS3.1</u> – Increase availability of floodplain habitat by 1,000 acres within 15 years of BDCP implementation, and channel margin habitat by 5 miles within 10 years of BDCP implementation, for spring-run migration and rearing compared to baseline conditions.

BDCP Goal L4 - Reduce mortality of covered species in the Plan Area.

<u>BDCP Objective L4.2</u> - Manage the distribution and abundance of established nonnative predators in the Delta to reduce predation on native covered fish species

<u>BDCP Objective L4.3</u> - Manage the distribution of covered fish species to minimize movements into high predation risk areas of the Delta

<u>BDCP Objective L4.4</u> - Reduce entrainment, impingement, and salvage losses of covered fish species

BDCP Goal L2 – Ecological processes and conditions that sustain and reestablish natural communities and native species

<u>BDCP Objective L2.9</u> – Provide refuge habitat for migrating and resident covered fish species

<u>BDCP Objective L2.10</u> – Increase the abundance and productivity of plankton and invertebrate species that provide food production for covered fish species in the Delta waterways

BDCP Goal L3 – Capacity for movement of native organisms and genetic exchange among populations necessary to sustain native fish and wildlife species in the Plan Area

<u>BDCP Objective L3.3</u> – Support the movement of larval and juvenile life stages of native fish species to downstream rearing habitats

Stressor: Predation

Predation is identified as a driver that exerts negative pressure on juvenile salmonids migrating through the Delta (Williams 2010). This relationship is characterized as having a medium level of understanding, importance, and predictability (Williams 2010). The Plan proposes to address predation through several means including predator control (CM15), alternative migration routes (CM2 and CM16), invasive aquatic vegetation control (CM13), and water facilities and operations (CM1). Other conservation measures, such as those related to restoration of seasonally inundated floodplain (CM5), channel margins (CM6), riparian communities (CM7), and tidal communities (CM4) may also reduce predation risk for juvenile salmonids, among other benefits.

Predator Control - Conservation Measure 15

BDCP Objective: L4.2 - Manage the distribution and abundance of established nonnative predators in the Delta to reduce predation on native covered fish species.

Relation to Global Objectives: Conservation Measure 15 (Predator Control) has been proposed as a means to reduce local effects of predators by conducting control activities at "hot spots." Such an effort is intended to reduce predator density in the Plan Area to achieve a measurable decrease in spring-run Chinook salmon predation with 15 years of Plan implementation.

Indicator:
- Predator fish species at local scales
- Predator "hot spots"
- Survival of juvenile spring-run Chinook salmon

Locations: Throughout Plan Area. The Implementation Office will review fish monitoring data, bathymetry data, and radio and acoustic tagging study results to determine the locations and causes of predator hot spots throughout the Plan Area.

Timing (e.g., seasonality) of stressor reduction: Daily focused removal methods when sensitive life-stages of covered fish species are present. Removal/modification of structures that provide predator hiding spots will be conducted at times when the potential capture of covered fish species can be avoided or minimized.

Attribute:
- Diversity, abundance/density, distribution, and size of predatory fish within specific reaches/locations
- Spatial distribution and prevalence of predator "hot spots"
- Improved survival of juvenile spring-run Chinook salmon during migration through Delta/specific reaches (acoustic tagging studies)

Quantity or State:
- Reduced densities of predatory fish species (target: daily focused removal)
- Reduced occurrence of sites or features that represent predator "hot spots" (target: 10-20 structures removed per year, 5-10 boats removed per year)

- Measurable decrease in predation on emigrating juvenile spring-run Chinook salmon
- Improved survival of juvenile spring-run Chinook salmon during migration through specific reaches where predator removal or structural modifications/removal has occurred (target for through Delta survival has not been identified)

Time Frame: Initial inventory and screening actions are expected to take two years with initial control actions beginning in year three of Plan implementation.

Confidence that "Quantity or State" are sufficient to attain Objective:
While there is good evidence that predation in the Delta is significant, the actual extent of predation remains uncertain (Williams 2010). In addition, few direct estimates of predation rates and effectiveness are available. The ability of predator control actions to substantially and cost-effectively benefit covered fish species is not known. There are a number of uncertainties related to predator control efforts, including:

- Will the reduction in the number of predators at specific locations be sufficiently large to (1) be detectable with respect to estimates of predator abundance and (2) to test the underlying hypothesis that a reduction in the density of predators will improve survival of juvenile salmonids?
- What are the population-level and community-level responses of predators and covered species to localized predator removal efforts?
- Could removal of certain predators (e.g., striped bass) release other predator and/or competitor populations from predation pressure?
- Potential unintended changes to the targeted predator populations (e.g., shift population to smaller fish that are less desirable to anglers, which may consume more smelt).
- Need to evaluate potential for cascading effects.
- In consideration of the relevant costs and benefits, how should efforts related to predator "hot spot" removal be prioritized?

Determine Effectiveness of Conservation Measure (Were expected outcomes achieved?):
Do predator control actions (removal of predators and/or structural modifications) affect survival of juvenile spring-run Chinook salmon emigrating through the Delta?

Given the degree of uncertainty and potential for negative ecological outcomes associated with this Conservation Measure, research actions designed to evaluate the potential effectiveness of the proposed actions is warranted prior to full-scale implementation.

Conclusions Needed

1. How effective are control measures?

    Examples of potential research actions (from Table 3.E-8) – Before and after studies evaluating the density and abundance of predators at removal location and nearby sites. Survival of covered fish species before and after predator removal in reaches with and without control efforts

    1a. Was the reduction in number of predators at specific locations sufficiently large to be detectable with respect to estimates of predator abundance?
    1b. Were predatory fish numbers reduced or simply redistributed?

1c. Did the age class structure and size of predatory fish change in response to the control measures?
1d. Did survival rates increase in reaches following predator removal activities?
1e. Did survival rates increase in reaches following removal or modifications of artificial structures?

2. How do mortality rates due to predation that were estimated using hatchery-reared salmon juveniles compare to those of natural spawned salmon?
3. Did the control measures result in enhanced effectiveness of other predators and/or competitors through reduced predation pressures?
4. How effective can changes in release practices (hatcheries and salvaged fish) be in enhancing survival rates of juvenile Chinook salmon.

Alternative Migration Route(s) – Conservation Measures 2 and 16

<u>BDCP Objective:</u> <u>L4.3</u> - Manage the distribution of covered fish species to minimize movements into high predation risk areas of the Delta

<u>Relation to Global Objectives:</u>

<u>Indicator:</u>

<u>Locations:</u>

<u>Timing (e.g., seasonality) of stressor reduction:</u>

<u>Attribute:</u>

<u>Quantity or State:</u>

<u>Time Frame:</u>

<u>Confidence that “Quantity or State” are sufficient to attain Objective:</u>

Table 3.E-8. Key Uncertainties, Potential Research Actions, and Relevant Conservation Measures

Number	Key Uncertainty	Potential Research Actions	Relevant Conservation Measure(s)
1	What are the population sizes of covered fish species and to what extent does the distribution of the smelts extent upstream?	• Estimate population sizes of species for which no reasonable estimates have been made, using existing survey data or through development of additional surveys • Conduct additional trawl surveys to assess proportion of delta and longfin smelt populations occurring in the vicinity of the north Delta intakes	• CM1 Water Facilities and Operations
2	What are salvage losses for covered fish species at the south Delta export facilities?	• Determine total losses during the salvage process (i.e., prescreen losses, and losses during collection, handling, transport, and release)	• CM1 Water Facilities and Operations
3	What is the relationship between Delta Cross channel operation, covered fish movement and survival, and tidal flows?	• Document effects of Delta Cross Channel operations on hydrodynamics and fish migration.	• CM1 Water Facilities and Operations
4	How will operations using the new water facilities affect impingement, entrainment, and predation on covered fish species?	• Determine the extent and patterns of predator aggregation at north Delta intakes, particularly in comparison to patterns at the existing, mostly revetted river banks. • Determine the magnitude of losses of covered fish due to entrainment, impingement, and predation at these facilities, including near-field and far-field effects (i.e., to what extent are fish drawn towards the intake in relation to their lateral channel position) • Determine the changes in central Delta predation attributable to altered flow downstream of the new north Delta intake which may affect fish migration pathways. • Determine how new water operations affect magnitude and timing of predation near the south Delta facilities, especially in Clifton Court Forebay. • Evaluate San Joaquin River salmonid outmigration survival with south Delta facilities turned off (i.e., following implementation of the north Delta diversions) in order to inform potential effectiveness of isolating Old River	• CM1 Water Facilities and Operations

		Determine changes in through-Delta survival following implementation of Plan operations	
5	How do Plan operations affect upstream migration of anadromous covered fishes?	• Evaluate if increased inundation of Yolo Bypass attracts more upstream migrating adult fish species away from the Sacramento River and into the Bypass • Evaluate if there is increased straying of Sacramento River-origin adult fish as a result of reduced Sacramento River flows • Evaluate if there is there is improved homing of San Joaquin River-origin adult fish as a result of reduced Sacramento River flows • Determine if covered fish species are caught as bycatch during predator removal efforts and assess ways to reduce such bycatch, if necessary • Evaluate if nonphysical barriers delay upstream migration of covered anadromous fishes	• CM1 Water Facilities and Operations • CM2 Yolo Bypass Fisheries Enhancement • CM15 Predator Control • CM16 Nonphysical Fish Barriers
6	Do the modifications at Yolo Bypass function as expected, and if so, how effective are they?	• Evaluate the effectiveness of the fish passage gates at Fremont Weir. • Evaluate the effectiveness of the sturgeon ramps. • Determine whether stilling basin modification has reduced stranding risk for covered fishes. • Determine if increased inundation rates have changed stranding risk for covered fish on the Yolo Bypass floodplain and its perennial ponds. • Determine whether Sacramento Weir improvements have benefited fish passage and minimized stranding risk. • Determine effectiveness of Tule Canal/Toe Drain and Lisbon Weir improvements to reduce the delay, stranding, and loss of upstream migrating adult salmon, steelhead, and sturgeon. • Determine growth rates of juvenile salmonids that have entered the Yolo Bypass during Fremont Weir operation. • Document Sacramento splittail spawning and spawning success in the Yolo Bypass during Fremont Weir operation. • Evaluate whether the Lower Putah Creek realignment has improved upstream and downstream passage by covered fish. • Determine severity of predation effects on covered fish using the Yolo Bypass. • Assess residence time and survival of larger juvenile salmonids	• CM2 Yolo Bypass Fisheries Enhancement

		using the Yolo Bypass as an alternative migratory route through the Delta	
7	Do increased frequency and duration of flooding in Yolo Bypass affect the health and vigor of elderberry shrubs and other valley/foothill riparian vegetation in the Yolo Bypass?	• Monitor key indices of plant health and vigor for elderberry shrubs and other riparian species at selected sites prior to implementation of CM2, and at regular intervals (to be determined) following Fremont Weir improvements.	• CM2 Yolo Bypass Fisheries Enhancement
8	How does tidal marsh restoration affect production of food for covered fish and export of this food to suitable habitat?	• Quantify the primary and secondary production, including food suitable for covered species, exported from restored tidal marsh plain into adjacent restored subtidal aquatic habitat areas.	• CM4 Tidal Natural Communities Restoration
9	How have hydrodynamic changes associated with tidal restoration affected organic carbon export rates?	• Document the export of organic carbon produced in restored tidal marsh plain into existing Plan Area channels.	• CM4 Tidal Natural Communities Restoration
10	How has tidal marsh restoration affected benthic invertebrate communities?	• Determine the extent and patterns of establishment of nonnative clams in restored subtidal aquatic habitats, particularly in relation to physicochemical parameters.	• CM4 Tidal Natural Communities Restoration
11	How are invasive filter feeders (Asian clams) affecting zooplankton production in restored tidelands?	• Compare zooplankton production in areas restored at different points in time (or with differing densities of clams) in order to judge comparisons	• CM4 Tidal Natural Communities Restoration
12	How is temporal habitat loss resulting from tidal natural communities restoration affecting saltmarsh harvest mouse and Suisun shrew?	• On restored tidal brackish marsh, perform a capture and release tagging study to determine colonization rate, abundance, and distribution of salt marsh harvest mouse. • On lands adjacent to planned tidal restored, perform capture and release tagging study to determine whether a sufficient population of salt marsh harvest mouse exists to serve as a source population for recolonizing newly restored areas. • Conduct similar studies on Suisun shrew.	• CM4 Tidal Natural Communities Restoration
13	What is the rate of genetic exchange between giant garter snake subpopulations in the Plan Area?	• Collect genetic material from giant garter snakes found in Coldani Marsh/White Slough, Yolo Basin/Willow Slough, and the Stones Lakes National Wildlife Refuge and every ten years perform a genetic analysis to determine the likely rate of of genetic exchange between the three locations or to identify signs of genetic isolation.	• CM4 Tidal Natural Communities Restoration

14	Will delta smelt spawn in sand-substrate tidal channels?	• Delta smelt appear to be spawning habitat limited. Sandy substrates desirable. Do they use sand-bottom tidal channels for spawning, and if so, is it feasible to design tidal restoration areas to achieve sand substrate drainage channels? Artificial sand supplementation also a possibility if current velocities are adequate to keep it silt-free.	• CM4 Tidal Natural Communities Restoration
15	Is it feasible to design tidal restoration sites to achieve tidal flow velocities that preclude rooting by invasive vascular plants?	• Empirical and lab studies to determine flow constraints on rooting of principal Delta aquatic weed species. • Model studies to assess velocity field for alternative restoration site design. • Field tests in restoration site projects.	• CM4 Tidal Natural Communities Restoration • CM13 Invasive Aquatic Vegetation Control
16	How is predation affecting covered fishes in restored natural communites?	• Evaluate the distribution and abundance of covered fish species and predators at restoration sites and compare to existing areas, particularly in relation to differences in physicochemical parameters. • Experimentally evaluate predation rates in restored areas and existing areas (e.g., tethering studies).	• CM4 Tidal Natural Communities Restoration • CM5 Seasonally inundated Floodplain Restoration • CM6 Channel Margin Habitat Enhancement
17	What is the status and trend of riparian brush rabbit populations in the Plan Area?	• Perform live-trapping of riparian brush rabbit biannually in suitable riparian brush rabbit habitat in Conservation Zone 7, using methods developed in coordination with the Endangered Species Recovery Program, to estimate status and trends of the riparian brush rabbit population in the Plan Area.	• CM5 Seasonally Inundated Floodplain Restoration • CM7 Riparian Natural Communities Restoration
18	How are restored natural communities being affected by invasive aquatic vegetation and have there been changes in existing areas?	• Evaluate the effect of tidal habitat restoration on the establishment of non-native submerged (SAV) and floating aquatic vegetation (FAV) in subtidal aquatic habitats. • Evaluate whether there have been changes in IAV that could be	• CM13 Invasive Aquatic Vegetation Control

		related to Plan operations (e.g., changes in Delta hydrodynamics)	
19	How extensive is invasive aquatic vegetation within areas of existing and potentially suitable delta and longfin smelt habitat?	• Evaluate the distribution of covered fish species in relation to SAV infestation.	• CM13 Invasive Aquatic Vegetation Control
20	How are herbicide applications to control invasive aquatic vegetation affecting the relationship between phytoplankton and *Microcystis*?	• Determine effects of water flow (residence time) and temperature on *Microcystis* blooms and its effects on phytoplankton.	• CM13 Invasive Aquatic Vegetation Control
21	Are aeration facility operations yielding measurable benefits to covered fish species?	• Evaluate if aeration increases survival and use of the Stockton DWSC as a migration route for covered fish species.	• CM14 Stockton Deep Water Ship Channel Oxygen Levels
22	In consideration of the relevant costs and benefits, how should we prioritize predator hotspots for removal?	• Document the extent and locations of fish predator hotspots within the Delta. • Before and after studies evaluating the density and abundance of predators at removal location and nearby sites (are fish numbers reduced or simply redistributed?)	• CM15 Predator Control
23	What are the population-level and community-level response of predators and covered species to localized predator removal?	• Abundance, age classes, and distribution of predators including striped bass, largemouth bass and other smaller piscivorous fish. • Survival of covered fish species before and after predator removal in reaches with and without control efforts	• CM15 Predator Control
24	How can we better understanding predator-prey interactions within the Delta?	• Evaluate extent of predation pressure on smelt eggs and larvae • Evaluate predation pressure on smelt juveniles and subadults • Determine significance of turbidity relative to predation on smelt in the Delta • Evaluate effects of predator removal activities on the competitive effectiveness of other predators or competitors. • Degree of predation/competition within floodplain on covered fish species. • Evaluate potential for cascading effects	• CM15 Predator Control
25	How effective are nonphysical barriers over the long term?	• Evaluate change in survivorship of covered species. • Evaluate effectiveness of barriers in high flow areas. • Monitor changes in proportion of covered species distribution and abundance upstream and downstream of barrier. • Evaluate behavioral response of covered species to barriers	• CM16 Nonphysical Fish Barriers

		Evaluate the effectiveness and permeability of non-physical barriers for outmigrating juvenile salmonids.	
26	How do nonphysical barriers affect predators?	• Determine the abundance of predators within the area of the non-physical barriers, both before and after installation, and evaluate the effect of the barriers on the survival of outmigrating juvenile salmonids. • Evaluate potential attraction of predators to fish non-physical barriers (i.e., type of predators, number of predators etc.). • Evaluate the extent of predator aggregation at non-physical barriers before and after installation. • Evaluate predator composition before and after installation of non-physical barriers. • Evaluate predator response to operation of non-physical barriers.	• CM16 Nonphysical Fish Barriers
27	Has increased enforcement reduced the incidence of poaching?	• Evaluate incidence of illegal take of covered species (especially salmon, steelhead, sturgeon)	• CM17 Illegal Harvest Management
28	Has increased enforcement had beneficial effects on anadromous fish stocks?	• Evaluate changes in population sizes and dynamics of green sturgeon, white sturgeon, and Chinook salmon	• CM17 Illegal Harvest Management
29	Has hatchery supplementation benefited natural populations of delta and longfin smelt?	• Evaluate effects of introduced hatchery-raised delta smelt and longfin smelt on wild populations.	• CM18 Conservation Hatcheries